PATENT SPECIFICATION

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COMPLETE SPECIFICATION

DRAWINGS ATTACHED

Improvements in or relating to Methods of and Apparatus for Producing Printing Blocks particularly Intaglio Printing Blocks

I, RUDOLF HELL, a German citizen, the personally responsible partner of Firma DR.-ING RUDOLF HELL, of 23 Kiel, 1-5 Grenzstrasse, Germany, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to methods of and apparatus for producing printing blocks, preferably intaglio printing blocks, from single-colour or multi-colour picture or text originals by photoelectric scanning of the picture original to be reproduced and, under the control of said scanning, removing material from the surface of the printing block.

In the production of printing blocks according to the picture telegraphy process, the picture original to be reproduced is scanned photoelectrically dot by dot in successive lines. The resulting fluctuating photocell signals control the depth of penetration of an engraving tool, which simultaneously with the scanning of the picture points engraves the screen elements in the surface of the printing block material. In the production of screen-type printing blocks, as is the case with relief and intaglio printing, the engraving tool also performs a movement vibrating regularly up and down with the aid of a screen frequency. Cutting, drilling, milling, or burning tools can be used as engraving tools. Generally, cutting tools have been used, by which both plastics material foils and metals can be engraved, and also burning engraving tools, the use of which however is restricted to decomposable materials such as plastics foils. The processes mentioned can be referred to as electromechanical or electrochemical processes.

The engraving speeds which can be achieved with the above mentioned methods depend on the fineness of the screens, that is to say on the number of screen dots per unit of length and the line density. In the case of relief printing it is possible to engrave up to 2,000, and in the case of intaglio printing up to 3,000 screen dots per second. It is not really possible to increase these engraving speeds, since there are limits to the speed at which the engraving tool still can be introduced into and removed from the printing block surface, because of the pressure effects and the risk of breaking the engraving tool, which may not be exceeded.

In addition, it is known to engrave printing blocks with the aid of focussed electron beams. If this corpuscular radiation has a sufficiently high power density, which can easily be brought about by focussing on the small screen elements, the electron beam can be used as a tool, for example as a drill, metal being for example evaporated at the points attacked. Given the use of sufficient beam current intensities and power densities, a considerable increase of the speed of engraving can be achieved with such an "electronic engraving machine" as it is referred to. The difficulty consists in that the entire machine must be placed in an evacuated vessel (an intaglio printing cylinder of a length of 2 metres for example should be considered in this connection). Since the mere cost makes this impossible, and in addition the vacuum must be regenerated from time to time because of the metal vapours produced, a multi-chamber pressure process has been proposed in which the electron beam is produced in a first chamber in a high vacuum by means of an electron gun, and then passed through a number of chambers with a vacuum decreasing in stages, until finally it is passed last of all through a short air gap at atmospheric pressure on to the material to be treated. Effici-

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ency however is lower than in a high vacuum, since in addition the ionisation work for the air gap to be passed through must be provided, and sharp focussing becomes more difficult.

In this " electronic " engraving of printing blocks, either the beam current intensity in the case of continuous operation or, in the case of pulse operation, the pulse frequency or the pulse amplitude or pulse length is modulated by the photocell signal.

Entirely new prospects now arise for a considerable increase of the speed of engraving, without the difficulties attendant upon high vacuum operation and the multi-chamber pressure process in electronic engraving, if high energy wave radiation, which is not to any great extent absorbed by the atmosphere, is used for engraving printing blocks.

According to the invention, " optical " engraving is effected by removing material from the surface of the printing block by a very highly bunched, monochromatic, bundle of light rays of high power density that is focussed on to the surface of the printing block, and modulating said bundle of light rays by the photocell signals.

The laser (L-ight A-mplification by S-timulated E-mission of R-adiation) which has been discovered in recent years is an optical maser (M-icrowave A-mplification by S-timulated E-mission of R-adiation), that is to say, a quantum-mechanical oscillator for the light wave range, particularly for the infrared range (about 1 μm-100 μm). The mode of operation of the laser cannot be gone into more fully here.

The laser is a light source which is extremely monochromatic, which has very considerable bunching with aperture angles of less than 1 minute of arc, which emits coherent light, and which has a high power of several hundred watts when operated pulse-wise. Solid-body lasers and gas lasers are to be distinguished. In the former the active medium consists for example of synthetic ruby which is doped with chromium ions, or else of fluorspar doped with samarium or uranium ions. Crystal lasers have a cylindrical shape with a diameter of about 5 to 10 mm and a length of about 5 to 20 cm. The circular end surfaces of the cylinder must be extremely plane-parallel in order to achieve good bunching, and are mirror surfaced. The crystal cylinder is at one and the same time the active medium and cavity resonator for the light wave trains produced by the forced emission. The excitation energy is radiated into the crystal by xenon flashlamps. In one convenient form of construction, the cylindrical flashlamp is situated in the one focal line and the cylindrical laser crystal in the other focal line of an internally mirrored elliptical cylinder. The entire light energy of the flashlamp is thereby focussed into the crystal and thus particularly well utilized.

The laser activity occurs only when the exciting pump power exceeds a certain threshold value. This threshold value can be reduced by about 1/3 if the ruby is cooled with liquid air. From the threshold value onwards the induced emission increases proportionally to the energy introduced. The excitation powers required for exciting the laser activity in the case of crystal lasers are at the present time still so great that they can be produced only in pulse form with xenon flashlamps. For continuous line operation, overheating of the laser crystal would occur.

In accordance with the pulse-wise excitation of the laser, the emission also proceeds pulse-wise in the form of light flashes. It is remarkable that the ruby laser exhibits the phenomenon of relaxation oscillations, that is to say the light pulse radiated off is broken up, in accordance with the light pulse of the exciting light source of for example 1 millisecond duration, into a plurality of individual light flashes each of a duration of a few microseconds. In the ruby laser, the time spacing of the micro flashes decreases with increasing pump power. It is interesting to note that the fluorspar laser doped with samarium ions exhibits no relaxation oscillations, but a continuous emission during the irradiation time. The fluorspar laser has good prospects of working in continuous operation if it is cooled with liquid air in order to reduce the pump power.

The gas laser consists of a quartz tube of a length of about 1 metre and a diameter of about 2 cm, which is filled with a helium-neon gas mixture. The quartz tube is closed by two highly plane-parallel, mirrored Fabry-Perot quartz plates. Excitation is effected here not by means of a light source, but by a gas discharge which is maintained by a high frequency generator with a frequency of about 30 Mc/s. In contrast to the crystal laser, the gas laser has continuous emission of rays, so that it can be operated continuously. A disadvantage is its low emitted light power, which amounts to only a few milliwatts.

With the aid of a small lens of short focal length, the laser bundle of light rays can easily be concentrated on a surface of 0.1 mm$\times$0.1 mm$=10^{-4}$cm^2. If we assume an emitted power of 100 watts (with the ruby laser radiation powers of several kilowatts with an aperture angle of 1° have already been achieved), this gives a power density of 10^6 Watts per cm^2=1 MW per cm^2. At this high power density, metals and even high temperature oxides evaporate. The above mentioned area of 0.1 mm$\times$0.1 mm is approximately the area of the screen cup in

conventional intaglio printing with a line density of 100 lines per centimetre.

There would be no point in using the continuously emitting laser for continuous operation except in the case of printing blocks which have no screen, that is to say for line blocks and line-screened intaglio printing blocks (without dot screening). In such cases the laser light beam would engrave juxtaposed furrows of uniform width and variable depth. The amplitude modulation of the laser light beam is effected in the manner known from picture telegraphy with the aid of a Kerr cell or similar devices, which are brought into the path of the rays between an analyser and a polariser. Apart from the fact that continuously working lasers at the present time still provide insufficiently high light powers for optical engraving, the interest in line-screened intaglio printing blocks is only slight, because of defective sharpness and lack of detail.

The crystal laser working pulse-wise, with its high pulse powers, provides great advantages for the production of dot-screened intaglio printing blocks. For this purpose the pulse frequency of the exciting flashlamp must be equal to the screen frequency, which can be achieved by suitable dimensioning of the discharge circuit, which is controlled by a screen frequency generator. The screen frequency must be derived from the rotation of the intaglio printing cylinder, since the latter must be in a fixed relationship to the former.

When the screen dot frequency in electromechanically engraved intaglio printing blocks is increased tenfold, that is to say to 30 kc/s, for optically engraved intaglio printing blocks using a laser as engraving tool, a pulse frequency of the flashlamp likewise equal to 30 kc/s is required. The light pulses of the exciting flashlamp and hence also the light flashes of the laser (without relaxation phenomena) accordingly have a time spacing of about 30 microseconds. In order that there may be no appreciable blurring, that is to say lengthening of the screen elements removed by evaporation in the direction of engraving, since the printing block continues to move during the time of action of a light flash, the pulse length must be small in relation to the pulse spacing, namely about 10% so that there is a maximum pulse duration of about 3 microseconds.

The modulation of the light flashes by the photocell signal can be effected in two ways, namely by modulating either the amplitude or the length (duration) of the pulses. The two types of modulation are equivalent, since the quantity of material evaporated depends on the product of amplitude and time duration, that is to say energy density. Pulse length modulation, particularly when symmetrical, is more complicated than pulse amplitude modulation, and for both types of modulation a number of methods are known to the expert from pulse and radar techniques. In addition, the modulation can be effected both electrically in the discharge circuit of the exciting flashlamp and optically on the emitted laser light by means of Kerr cells or similar devices. Since the latter are also electrically controlled, the modulation on the input or output side is in any case of electrical nature.

The modulation of the light by the photocell signal is very sensitive. Similarly to electronic engraving by means of corpuscular beams, the degree of modulation of the amplitude or time may amount to only a few tenths per thousand in order to cover the entire tone value range between black and white, which corresponds to a variation of cup depth between zero and about 0.05 mm.

It may also be mentioned that printing blocks without dot screens, that is to say line blocks or line-screened intaglio printing blocks, could also be engraved by means of a laser working pulse-wise. In the case of line-screened intaglio printing blocks which reproduce half-tones, although in an unsatisfactory manner, the impulse density would have to be modulated spatially, that is to say the pulse frequency would have to be modulated in respect of time, by the photocell signal. Although methods of pulse frequency modulation are known, the frequency of light pulses of flashlamps could be modulated only with difficulty, since in order to avoid screen-like structures, the frequency would already come within the high frequency range. Line blocks on the other hand could be produced with greater prospect of success by means of a laser operating pulse-wise. The pulse frequency is in this case, although very high, nevertheless constant so that, corresponding to the signals black and white, it would merely have to be gated and blocked. A possibility of producing (unmodulated) pulse high frequencies would comprise continuous signal operation of a ruby laser with relaxation phenomena. In this case pulse frequencies of the emitted light flashes of about 1 Mc/s could be obtained.

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings which show some embodiments of apparatus according thereto, by way of example, and in which:—

Figure 1 shows an embodiment of apparatus according to the invention, in which the intensity of the light pulses is modulated by the photo-cell signals, and

Figure 2 shows a second embodiment in which the duration (length) of the light pulses is modulated by the photo-cell signals.

Referring now to the drawings, in Figure

1, a motor 1 drives a cylinder 3 via a shaft 2, the original material 4 to be reproduced, and the printing block material 5 to be operated upon being fixed to the said cylinder 3. Along a generatrix of the cylinder, a photoelectric scanning device which will be described hereinafter is guided along in the zone of the original material 4 and a laser is guided along in the zone of the printing block, each by a support (not shown), in the manner of the arrangement of the screw-cutting lathe, in the direction of the arrow, with a feed per revolution corresponding to the selected line spacing (about 0.1 mm).

In practice, in the case of very long cylinders it is better to use two separate machines, one containing the master cylinder and the other the printing cylinder. It will be apparent that in this case the two machines must run in complete synchronism. For enlargements or reductions of the printing blocks in relation to the original, separate machines must be used for the original and for the printing blocks with exchangeable cylinders of different diameters. The speeds of advance of the two machines must then be adjusted in accordance with the selected scale of reproduction and the selected screen number.

Furthermore it is possible to use a plurality of scanning devices as well as a plurality of lasers, and by this means the operation may be accelerated.

In the embodiment illustrated, the photoelectric scanning device consists of a point source of light 6 which illuminates a small spot on the original material 4 by means of a lens 7, and of a lens 8 which collects the light reflected from the surface of the material 4, and concentrates it on the cathode of a photocell 9. The photocell currents oscillating in accordance with the brightness of the original material 4 are amplified in a D.C. amplifier 10 and fed to the condenser plates of a Kerr cell 11, which is located between two crossed polarisation prisms 12 and 13 in the beam of the laser. In this way, a modulation of the intensity of the light pulses emerging from the laser is obtained. The bundle of light rays from the laser is concentrated by means of a lens 14 on to the surface of the printing block to be worked. The laser consists of an elliptical cylinder 15 mirrored on the inside, the cylindrical flashlamp 16 being located in one focal line of the cylinder 15 and the cylindrical laser crystals 17 being located in its other focal line.

As stated above, the pulse frequency of the exciting flashlamp 16 fed from a high voltage generator 18 must equal the screen frequency.

This is obtained by means of a disc 19 fixed to the shaft 2, provided with a circular slit 20 arranged concentrically with the axis of the disc and formed by sections of the material of the disc which are of the same length and alternate between unremoved, or opaque, sections and removed, or transparent, sections. The number of these sections is such that the light leaving a point-source light 21, passing through an objective 22 and the slit 20, and collected by an objective 23 and concentrated on the cathode of the photocell 24, is subdivided in synchronism with this screen frequency. The pulsating D.C. accordingly supplied by a photocell 24 is amplified in an amplifier 25 and used to open a scanning stage 26 for a short moment for each pulse, a high voltage pulse of constant duration passing in each case from the generator 18 to the flashlamp 16.

In another embodiment of apparatus according to the invention, and shown in Figure 2, the lamp 16 may operate continuously and the bundle of light rays emerging from the laser crystal 17 be continuously emitted.

Like parts in the arrangements of Figures 1 and 2 have been given the same reference numerals and the operation of the arrangement of Figure 2 is as follows:

The picture signal supplied by the amplifier 10 is scanned by a scanner 27, which may be a rotating or electronic switch, briefly, pulse-wise and periodically, at a frequency which is derived with the elements 19-25 as in the arrangement of Figure 1.

The scanned, amplitude-modulated pulses of constant length (duration) are fed to a pulse-length modulator 28, which transforms them into time-modulated pulses of constant amplitude with a length (duration) proportional to the amplitude of the scanning pulses.

Such a pulse-length modulator essentially consists of a condenser rapidly charged by the scanning pulse to a voltage proportional to its amplitude and immediately thereafter slowly discharged by a resistor down to a constant remanent voltage. This means that the longest discharge period corresponds to the largest pulse amplitude. The discharge time elapsing until the variable condenser voltage has dropped to the constant remanent voltage is proportional to the charge voltage and therefore to the pulse amplitude. The variable saw-toothed voltage thus obtained is then clipped by a maximum value limiter to the value of the remanent voltage, thus giving the time-modulated pulses of constant amplitude.

These time-modulated pulses of constant amplitude are used in this case to open scanning stages 29 for a period corresponding to the pulse length, high voltage passing during this period from the generator 18 to the lamp 16. Hence the length of the light flashes supplied by the lamp 16 and consequently the length (duration) of the light pulses thereby

released, emerging from the laser crystal 17, are equal to the length of the time-modulated pulses controlling the scanning steps 29. Thus the length (duration) of the light pulses is modulated by the photocell signals.

In all embodiments of the invention, provision must be made for adequate cooling of the intaglio printing cylinder. In addition, the metal vapour produced must be permanently exhausted.

WHAT I CLAIM IS:—

1. A method of producing printing blocks, preferably intaglio printing blocks, from single-coloured or multi-coloured picture or text originals by photoelectrically scanning such originals to be reproduced and removing material from the surface of such blocks under the control of such scanning, said method comprising the steps of evaporating the material on the surface of such blocks by a very highly bunched, monochromatic bundle of light rays of high power density that is focussed on to said surface of said blocks, and modulating said bundle of light rays by the photocell signals.

2. A method as claimed in claim 1, wherein, for the production of printing blocks without screening, the bundle of light rays is emitted continuously, and the light intensity is modulated by the photocell signals.

3. A method as claimed in claim 1, wherein, for the production of printing blocks without screening, the bundle of light rays is emitted pulse-wise, and the frequency of the light pulses is modulated by the photocell signals.

4. A method as claimed in claim 1, wherein, for the production of screened printing blocks, the bundle of light rays is emitted pulse-wise with a frequency which is equal to the screen dot frequency, and the intensity of the light pulses is modulated by the photocell signals.

5. A method as claimed in claim 1, wherein, for the production of screened printing blocks, the bundle of light rays is emitted pulse-wise with a frequency which is equal to the screen dot frequency, and the duration (length) of the light pulses is modulated by the photocell signals.

6. Apparatus for carrying out a method as claimed in any one of claims 1-5, wherein a laser is used as the light source.

7. Methods for producing printing blocks, substantially as hereinbefore specifically described, with reference to Figure 1 or to Figure 2 of the accompanying drawings.

8. Apparatus for producing printing blocks, substantially as hereinbefore described with reference to Figure 1 of the accompanying drawings.

9. Apparatus for producing printing blocks, substantially as hereinbefore described with reference to Figure 2 of the accompanying drawings.

BARON & WARREN,
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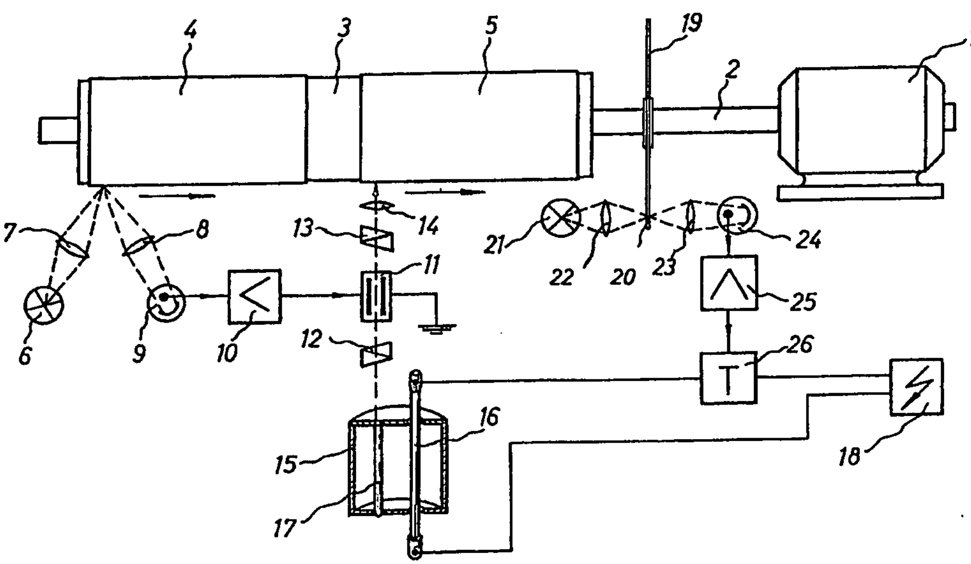

Fig. 1

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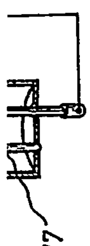

Fig. 1

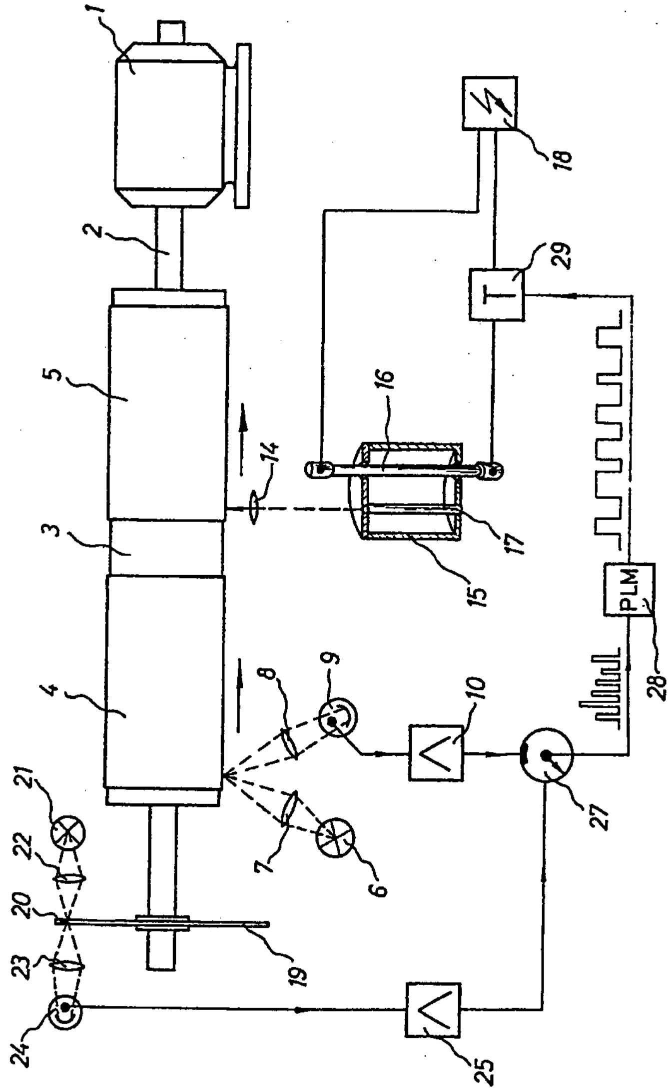

Fig. 2

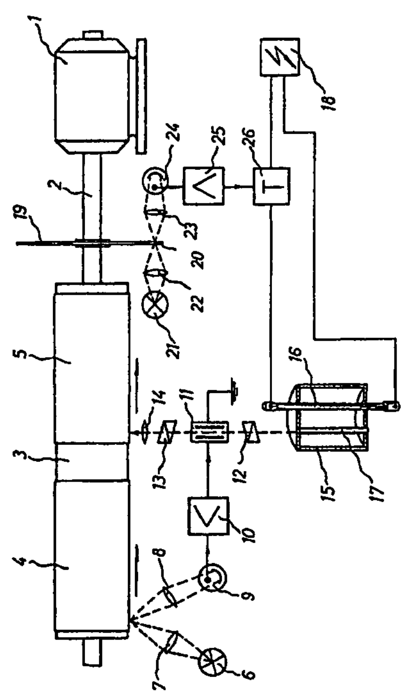
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Fig. 1

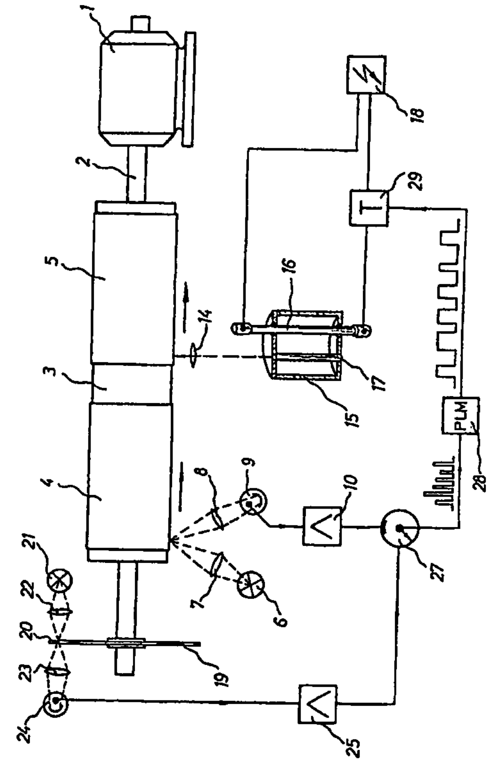
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Fig. 2